



# RFID in the healthcare supply chain: usage and application

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## Abstract

**Purpose** – The purposes of this study are to first, determine the most efficient and cost effective portions of the healthcare supply chain in which radio frequency identification devices (RFID) can be implemented. Second, provide specific examples of RFID implementation and show how these business applications will add to the effectiveness of the healthcare supply chain. And third, to describe the current state of RFID technology and to give practical information for managers in the healthcare sector to make sound decisions about the possible implementation of RFID technology within their organizations.

**Design/methodology/approach** – Healthcare industry literature was reviewed and examples of specific instances of RFID implementation were examined using an integrated simulation model developed with Excel, @Risk and Visio software tools.

**Findings** – Analysis showed that the cost of implementing current RFID technology is too expensive for broad and sweeping implementation within the healthcare sector at this time. However, several example applications have been identified in which this technology can be effectively leveraged in a cost-effective way.

**Practical implications** – This study shows that RFID technology has come a long way in the recent past and has potential to improve healthcare sector productivity and efficiency. Implementation by large companies such as Wal-mart has helped to make the technology become much more economical in its per unit cost as well as its supporting equipment and training costs.

**Originality/value** – The originality of this study lies in the idea that few practical and pragmatic approaches have been taken within the academic field of study for the implementation of RFID into the healthcare supply chain. Much of the research has focused on specific companies or portions of the supply chain and not the entire supply chain. Also, many of the papers have discussed the future of the supply chain that is heavily dependent on advances in RFID technology. A few viable applications of how RFID technology can be implemented in the healthcare supply chain are presented and how the current state of technology limits the broad use and implementation of this technology in the healthcare industry.

**Keywords** Radio systems, Health services, Value chain, Supply chain management, Pharmaceutical products, Patient care

**Paper type** Research paper

## Introduction

The motivation for undertaking this study was the simply overwhelming opportunity to improve the healthcare supply chain by looking at possibilities of exploiting RFID technology. With improvements, end customers and patients will receive better service while mistakes in treatment of patients or underutilization of equipment in the hospitals will be minimized. Many existing studies also suggest that proper management of RFID technology implementation may enhance healthcare services and products by lowering costs, improving the quality of care, and make patient care



more reliable and consistent by properly managing and tracking information and material flows (Angeles, 2005; Bacheldor, 2007a; Murphy and Kay, 2004; O'Connor, 2007a; Neil, 2005; Schwirn, 2006a, b; Wang *et al.*, 2006; Swedberg, 2007; Thompson, 2004).

RFIDs, or radio frequency identification tags, are electronic chips embedded within or very near a product or shipment. They serve as a tool of remotely tracking supplies, equipment, and even people as they move through the supply chain from manufacturers to suppliers, wholesalers, hospitals, pharmacies, intermediaries, and end customers as well as their movement within a single firm (Bacheldor, 2007b; Bowersox *et al.*, 2007; Chopra and Sodhi, 2007; Glabman, 2004; Riggins, 2006; Sarma, 2004). There are two main types of tags, active and passive. Active tags constantly transmit radio signals so that a shipment or product can instantly be located in a warehouse or building. Active tags are generally known as Gen 2 tags and can usually be identified and categorized as any tag that is able to transmit a signal further than 3 meters. These tags vary in price greatly depending on the requirements of use, but could be said to range from \$0.50 to \$50. Passive tags do not emit the radio signal, but respond to a RFID scanner when the product or shipment is placed through the scanning portal (Bowersox *et al.*, 2007). These usually respond only to signals sent from less than three meters away. The costs of this type of tag are much lower and getting lower everyday. Costs can range from \$0.05 to \$0.50. Firms that require little information to be kept and updated as the product travels through the supply chain usually use these tags. The more economical tags usually contain the least information (Hartman *et al.*, 2004; Schwirn, 2006c).

Currently, RFID technology is widely available and relatively easy to integrate into the healthcare supply chain (Angeles, 2005; Chopra and Sodhi, 2007; Davis, 2004). The training, technology, and necessary collaboration are all within reach of most customers and suppliers, however, the costs are still prohibitive for many participants. The cost of the individual RFID tags, the cost of the tag readers, and the cost of creating a singular and unified system that is easily adopted by all players in the supply chain are the reasons RFID is not currently utilized to its full extent (Chopra and Sodhi, 2007). At this time, we believe only a small number of users and portions of the healthcare supply chain can effectively implement this technology to a limited set of business applications, at the current cost levels. Current use of RFID in the healthcare supply chain is not only limited due to the high cost, but also the unknowns associated with full implementation of a system based on this technology (Bacheldor, 2007a, b; Chopra and Sodhi, 2007; Murphy, 2006).

Our preliminary hypothesis is that there will be limited benefits of RFID knowledge within the healthcare supply chain with the current level of existing technology. A second hypothesis is that only certain portions of the healthcare supply chain will benefit enough to justify the cost of implementation, such as procurement and in-house operations.

The purpose of this research study is to first, determine the benefits and drawbacks of implementing current RFID technology into the healthcare supply chain. Second, determine which areas of the healthcare supply chain would benefit the most from these implementations (suppliers, distributors, manufacturers, retailers, healthcare professionals, consumers), and give examples of this. And finally, see how RFID has affected the hospital value chain and to see what cost savings and consumer benefits

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can be expected by giving a few examples of the use of RFID tags in primary care facilities.

### **RFID potential in health care**

This section provides an overview of the current use of RFID technology, supporting IT infrastructure, potential applications, and key factors for its successful implementation in healthcare supply chains.

#### *Current use of RFID*

Relatively speaking, there is a great deal of information and research done on the application of RFID technology into the healthcare sector (Schwirn, 2006b, c). However, much of the research addresses the future potential of the technology and speaks little of the actual use in today's business environment. What this means is that there are a great deal of forward thinking articles and studies regarding the future costs of the tags, the readers, and complete implementation, but little of the actual costs of implementing RFID systems today for the average manager. In reading many studies, articles, and papers it is widely reported that the healthcare supply chain has begun to undertake selective and targeted RFID based system implementation (Bacheldor, 2007a, c; O'Connor, 2007a; Neil, 2005; Wang *et al.*, 2006; Swedberg, 2007; Fish and Forrest, 2007).

#### *IT infrastructure needed moving forward*

The IT infrastructure needed for a firm to incorporate and harness the full potential of RFID in the healthcare supply chain is well developed. The vast amount of technology, from readers to servers, needed to implement RFID technology is also currently available. However, the expense to implement the technology is staggering and only a few large firms have been able to incorporate the technology needed into their systems processes effectively (Fanberg *et al.*, 2004; Frost & Sullivan, 2004; Glabman, 2004).

#### *Predicted applications*

The articles and studies researched for this paper largely involve future applications and predicted applications. Nearly all of the articles focus on eventual applications of RFID in the supply chain and more specifically, the healthcare supply chain. The future seems to point in the direction of full incorporation of RFID tagging with nearly all products, equipment, supplies, and people simply because of the wide range of use of these tags (Angeles, 2005; Chopra and Sodhi, 2007; Riggins, 2006; Sarma, 2004; Schwirn, 2006c; Fish and Forrest, 2007).

However, even though the long-term future for RFID technology appears promising, RFID implementation and uses are uncertain in the near future. One article in particular pointed to the fact that the costs and ROI are too high for widespread implementation, and that any product that is lower than \$15 in price would be a poor use of resources (Angeles, 2005; Schwirn, 2006b). What this means is that many medical supplies in certain portions of the supply chain are simply too low cost to justify using RFID technology. The article went further to say that upstream manufacturers are not going to incorporate RFID in anything but the palate level due to costs, leaving the down stream users without the RFID tags.

### *Keys to success*

There are three keys to success moving forward with RFID technology: collaboration, long-term relationships, and capital investment (Fish and Forrest, 2007).

First of all, supply chain collaboration must take place in order for each player to know the down stream as well as up stream uses of their products. Suppliers must be willing to meet the needs of their customers in order to make this technology effective for implementation (O'Connor, 2007a; Neil, 2005; Swedberg, 2007; Thompson, 2004).

Second, with regard to collaboration in the supply chain, creating long term relationships is necessary to make this technology both unified with the wide range of technologies available and justify the equipment purchases and training. If Supplier X knows they will be working with Customer Y for years to come, they will be much more likely to make the capital investment to meet their needs; which brings us to the third thing, capital investments (Angeles, 2005).

Major capital investment will be needed upfront for all users of RFID technology. Readers, training, computer systems, and tags are all needed upfront to ensure proper use of RFID tagging. If these capital expenditures are made in collaboration with supply chain partners, it is much more likely that the costs will pay off in a more expedited manner (Angeles, 2005; Murphy, 2006).

It will take all three of these key elements together to ensure an opportunity for success. One piece alone will not lead to an effective use of company resources and would not be in the best interest of the supply chain. An amount of faith in collaboration along with proper financial planning may be needed to guarantee success.

### **Methodology**

RFID technology can provide many benefits for healthcare and pharmaceutical applications that allow service providers to design more efficient processes, reduce costs, improve service, and improve patient safety. However, current healthcare and supply chain management journals and articles also indicate that costs and return on investment (ROI) are a concern for most healthcare organizations thinking about implementing RFID (Murphy, 2006). Cost considerations, which influence ROI improvements, play a major role for adoption of RFID technology. Initial investment in equipment, software, training of personnel, and adjusting of business processes can run up a large bill in the first year or more of implementing RFID systems (Schwirn, 2006a, b, c). This study's methodology will focus on providing information and justification to alleviate the cost and ROI concerns of healthcare organizations considering RFID implementation.

There are two approaches to our methodology. The first approach relies heavily on reading and interpreting research and existing sources from healthcare and RFID supply-chain experts such as Frost and Sullivan, SRI Consulting Business Intelligence, and RFID Journal as well as articles and web sites (Bachelder, 2007a, b, c; Frost & Sullivan, 2004; O'Connor, 2007a, b; Schwirn, 2006a, b, c; Swedberg, 2007). This first approach identifies RFID technology, capability, and issues or concerns with implementation. The second approach relies on informal interviews with mothers to obtain estimated times during hospital process for childbirth (Bachelder, 2007c; Fanberg *et al.*, 2004; Riggins, 2006; Wang *et al.*, 2006). It is through this research that we plan to synthesize the needed information to demonstrate the benefits of RFID

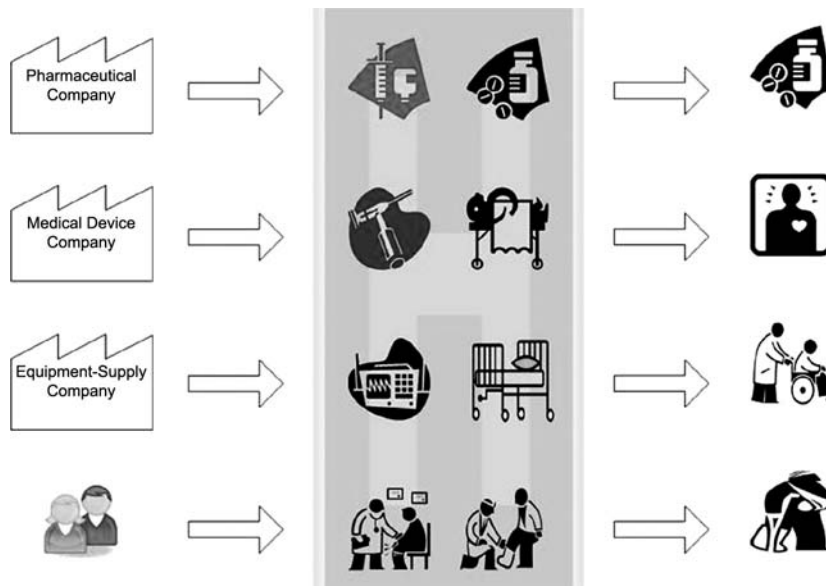
application and justify where expected applications could be implemented. We are relying on this type of research because of time, access, and financial restraints.

In brief, this methodology combines current industry research and informal survey data to map the childbirth delivery process for the healthcare industry. Once the value stream map is created, application of Lean Six Sigma methodology will facilitate analysis of business process and workflow (Rother and Shook, 2003).

### Analytical framework

There are many potential uses for RFID in the hospital and healthcare value chain. RFID applications can be used in the pharmaceuticals, medical device, and medical equipment, and patient supply chains. These RFID applications can control product diversion, protect against counterfeit drugs, and track medical devices. The various high level supply chains in hospitals are shown in Figure 1. One of the key uses of RFID is asset tracking and scheduling of hospital equipment (Glabman, 2004). Based on current industry research, this study assumes that implemented RFID will be capable of scheduling and checking availability of hospital beds and equipment for childbirth delivery. An additional assumption is that RFID will assist in information flow of patient data and facilitate electronic medical records.

The framework for this study utilizes the Lean Six Sigma tool of value stream mapping (VSM) (Rother and Shook, 2003). In short, VSM identifies the business process, material, and information flow regarding any particular process. While mainly used in manufacturing and industrial applications, VSM can be applied to healthcare processes to identify lead (wait) time and process (cycle) time. This study follows the framework of VSM by identifying the current state map, create and outline lean value stream potentials, and future state map.



**Figure 1.**  
High level hospital supply  
chains

The current state map is illustrated in Figure 2. The estimated times are based on informal interviews with mothers who delivered within the last three years. Mothers were asked to estimate the time it took for main processes for childbirth delivery. The estimated times were obtained during individual interviews. Each mother was asked to provide estimated time in minutes for each process as well as waiting time in-between main processes. The data collected and summary of the time estimates from each mother are shown in Table I.

From the current state map and collected data, the longest waiting period was post delivery, which is understandable due to recommended 24-48 hours waiting periods after the child is delivered. While about 80 percent of the mothers (three out of five) had very short waiting times prior to getting a delivery room and bed assigned, 20 percent of the mothers (two out of five) had significantly longer waiting periods. For these two mothers, the long Wait 2 time was due to scheduling and unavailability of delivery rooms and/or equipment. Mother B was admitted to a delivery room and bed, but was bumped several times from room to room due to reprioritization and unavailability of beds. Mother E was scheduled to have a water birth delivery, but during her scheduled visit, Mother E was informed that the equipment for water birth delivery was not working and unavailable.

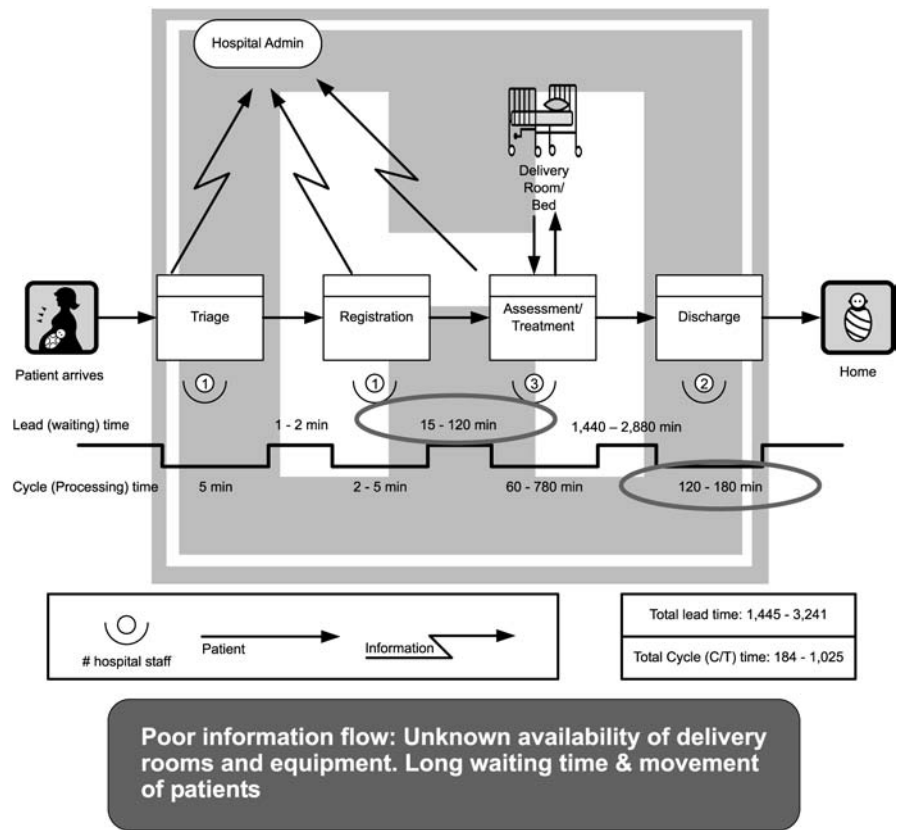


Figure 2.  
Current state map – child  
birth delivery

Current state	Baby	Triage	Wait 1	Registration	Wait 2	Treatment	Wait 3	Discharge	Lead	Cycle
Mother A	1	5	0	0	3	780	2,880	240	2,883	1,025
Mother A	2	3	0	1	5	60	1,440	120	1,445	184
Mother B	1	2	1	2	360	720	2,880	45	3,241	769
Mother C	1	3	1	15	0.5	570	2,160	60	2,161.5	648
Mother C	2	2	1	1	0.5	980	2,880	30	2,881.5	1,013
Mother D	1	1	0	0	2.5	540	2,880	15	2,882.5	556
Mother D	2	1	0	0	3	840	2,160	10	2,163	851
Mother E	1	3	1	0	180	600	1,440	120	1,621	723
Min		1	0	0	0.5	60	1,440	10	1,445	184
Max		5	1	15	360	980	2,880	240	3,241	1,025
Average		3	1	2	69	636	2,340	80	2,410	721

Table I.  
Mother survey data  
summary



Another area for improvement was the discharge process. During interview process, some mothers experienced long paperwork times prior to discharge. For child 1, Mother A experienced a four hour process for completing paperwork and supplemental information to complete the discharge process.

Based on survey information and application of value stream mapping, there are two areas where RFID application could assist with information flow to improve service time; Wait 2 time and Discharge. These processes could be improved by utilizing RFID applications to assist with scheduling and availability of delivery beds as well as the discharge process. Based on elimination of scheduling wait times, the estimated Wait 2 time and Discharge process for RFID enabled information flow and patient electronic medical records are summarized in Table II.

The future state map with RFID usage is illustrated in Figure 3. The key areas of information flow are provided by the red arrows, which facilitate information flow for delivery room and equipment availability as well as faster patient information. Using the current state and future state model for process and waiting times, Monte Carlo analysis was carried out using @Risk simulation software from Palisade Corporation, USA to estimate improved Wait 2 time and Discharge process times compared to the current state map. A comparison of future state process with the current state map shows that 20 percent of the patients can expect a 94 percent decrease in waiting time due to better scheduling, delivery room, and equipment availability. In addition, patients could potentially expect a 48 percent faster discharge time due to decreased paperwork and improved information flow. The simulation results using @ Risk software are shown in Figures 4 and 5.

### Findings/recommendations

Preliminary findings are showing a great potential for RFID type technologies within the healthcare sector. Costs and ROI questions one of the two biggest concerns regarding implementation of RFID. For cost justification of and minimization of ROI uncertainty, value stream mapping provides an appropriate tool to facilitate and obtain improvements.

With RFID application it is best to know your business processes prior to implementation. While this study only looks at a high level map for the birth delivery process, it is beneficial to go in depth and map other areas of the hospital supply chain. By applying Lean Six Sigma and value stream mapping to other supply chains, additional applications can be justified for implementation of RFID infrastructure (Rother and Shook, 2003).

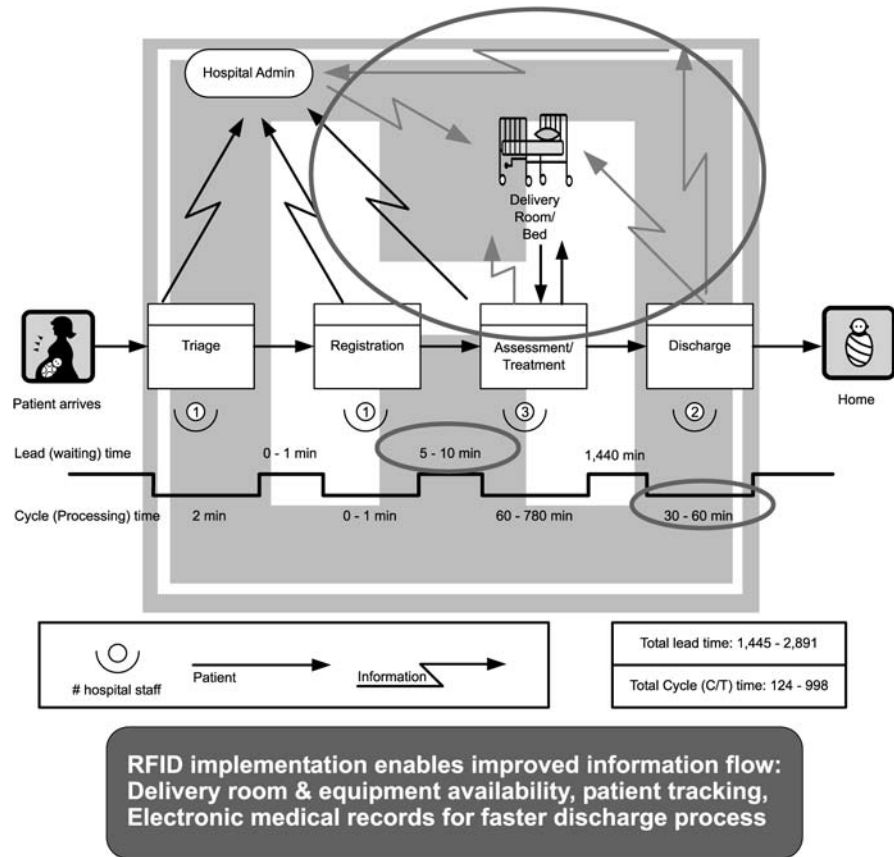
Another recommendation is to start RFID implementation with limited pilot testing for key applications such as equipment scheduling and availability, high cost hospital equipment tracking, high cost pharmaceuticals, and medical devices. Once the pilot test and training is completed for limited trials, RFID can expand to other application areas such as tracking of patients, medical waste, and laboratory and pathology samples (Angeles, 2005; Chopra and Sodhi, 2007; O'Connor, 2007a; Thompson, 2004).

Eventually, all supply chains should be considered as well as upstream vendors and suppliers. It is especially important to collaborate with supply chain partners, as there will be high costs if no communication is made regarding which technology and standards to be utilized. A key consideration with implementing RFID within all



Current state	Baby	Triage	Wait 1	Registration	Wait 2	Treatment	Wait 3	Discharge	Lead
Mother A	1	5	0	0	3	780	2,880	120	2,883
Mother A	2	3	0	1	5	60	1,440	60	1,445
Mother B	1	2	1	2	10	720	2,880	25	2,891
Mother C	1	3	1	15	0.5	570	2,160	30	2,161.5
Mother C	2	2	1	1	0.5	980	2,880	15	2,881.5
Mother D	1	1	0	0	2	540	2,880	15	2,882
Mother D	2	1	0	0	3	840	2,160	10	2,163
Mother E	1	3	1	0	10	600	1,440	60	1,451
Min		1	0	0	0.5	60	1,440	10	1,445
Max		5	1	15	10	980	2,880	120	2,891
Average		3	1	2	4	636	2,340	42	2,345

**Table II.**  
Estimated times for  
future state with RFID

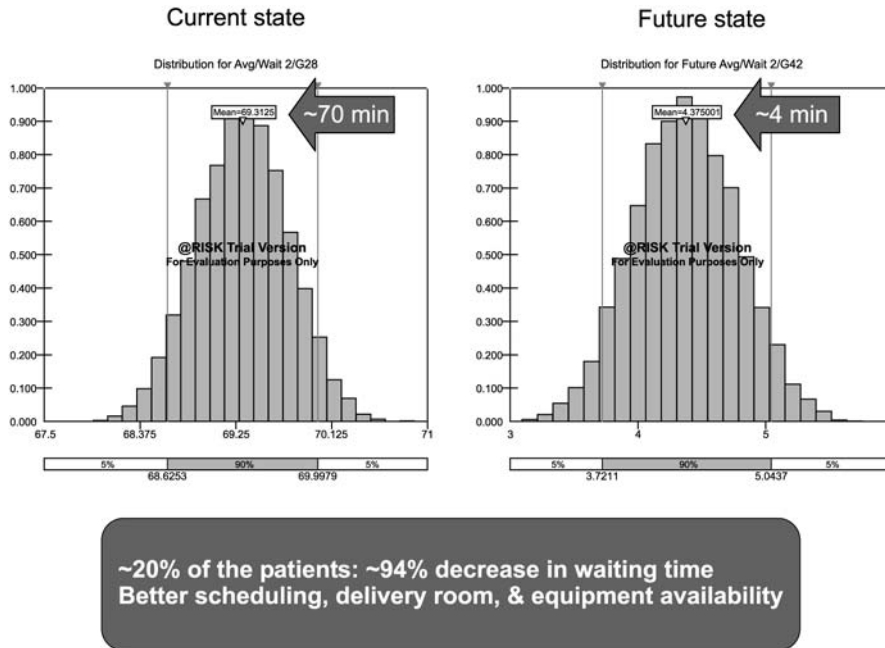


healthcare supply chains is compatibility of RFID infrastructure, which is vital for information flow.

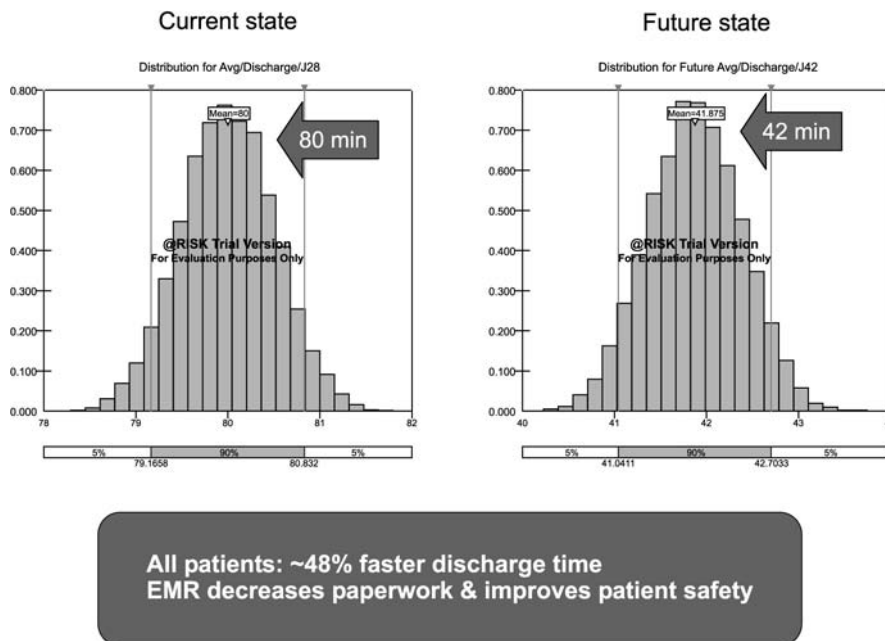
The area for cost-effective improvement within the chain is limited to a few key areas (procurement, in-house operations, and delivery). It seems there are limited uses for RFID in the supply chain at this time simply due to the high cost of implementation. It will be several years before medical manufacturers and pharmaceutical companies are willing to incorporate RFID technology into all products and equipment.

Given the advances in technology, it will not be long before nearly all supply-chains are integrated fully with similar technology. There has been a drive in the recent past to make sure all RFID tags and equipment can be universally used and harnessed in the supply chain. The frequency ranges and tag design limitations have become more universal, but it will take several years before these technologies are widely universal around the globe, from country to country and from company to company (Hartman *et al.*, 2004; Sarma, 2004).

The costs are prohibitive for fully integrating the healthcare supply chain at this time. With current technology being at around \$0.10 to \$0.50 per tag for passive technology and many times that for the Gen 2 active tags, it will be difficult to justify



**Figure 4.**  
Improved Wait 2 time –  
simulation results with  
@Risk



**Figure 5.**  
Improved discharge time  
– simulation results with  
@Risk

the cost of implementation across the entire supply chain for all medical products and equipment (Bowersox *et al.*, 2007; Chopra and Sodhi, 2007).

### Limitations

This study was constrained by the limited access to information due to the sensitive nature of medical records/history within the supply chain and availability of only a few basic studies in the professional literature.

The survey was limited to only five mothers and had limited healthcare professional input based on industry reports and articles only. In addition, only a high-level value stream map was created for the birth delivery process and hospital. An in-depth map and a pilot study could provide more verification and validation of initial time savings with additional resources.

As the next step, we would like to more fully study the willingness of actual managers in the healthcare supply chain to incorporate the technology. We are aware of the costs of implementation, but given more time, it would be useful to see where those that could make the biggest difference are at regarding RFID information. We would like to further explore the following questions specifically:

- Does hospital management believe in RFID applications and utilization?
- What is management's perception about the cost of RFID and return on investment?

### Managerial implications

The implications of integrating more use of technology related to supply-chain RFID devices are great. Time, money, effort, and patient deaths could all be greatly reduced with a proper implementation of this technology (Bowersox *et al.*, 2007; Chopra and Sodhi, 2007). Resources could be leveraged more with the implementation. Equipment, materials, and patients can be more effectively managed to lower overall operational costs. Time to locate materials and equipment will be greatly reduced and the contents can be immediately identified once the item is located. A history of the use of a product or piece of equipment can be kept and potential problems can be isolated much more quickly with proper records as a part of RFID technology (Angeles, 2005; Bacheldor, 2007a; Chopra and Sodhi, 2007). An example of this in a hospital could be incorporating RFID technology into all the portable equipment. The location of this product could be determined instantaneously and tracking records could be seamlessly kept with that piece of equipment (Neil, 2005; Swedberg, 2007). However, problems that arise could have harsh consequences as well. Dependence on technology could potentially raise prices in the end due to problems that are simply not known. What are theoretical costs at this point can easily move to disillusioned operation methods and cost overruns. With newer technology comes uncertainty, and with uncertainty comes great cost expenditures (Bacheldor, 2007a, b; Chopra and Sodhi, 2007).

### Value of the study

The contribution of this study lies in the practical applications and everyday uses of RFID technology for managers within the healthcare supply chain, namely, managers in pharmaceutical manufacturing and primary care providers. This study also serves as a practical primer to inform and bring managers up to speed with the current state of RFID technology and the possible and likely applications of this technology in the

healthcare sector. It is apparent after reading and reviewing the current literature and studies on the application of RFID technology that practical managerial steps and information is lacking. We hope to provide a way for managers to receive a high level of understanding and inspiration for incorporating current and future technologies into their own firms and supply chains.

## Conclusions

Investments into RFID technology should only be made for certain aspects of the supply chain at this time. The cost/benefit analysis identifies that RFID technology is very valuable, but at a great cost to integrate into a business (Kumar, 2007). Within a few years, RFID technology will be cheap enough to fully integrate not only into the healthcare supply chain, but also into most supply chains. However, at current prices, applications should be chosen carefully. In the healthcare supply chain, it should be limited to certain pharmaceuticals, portable equipment, and limited patient tracking (Angeles, 2005; Bacheldor, 2007a, b; Bowersox *et al.*, 2007; Chopra and Sodhi, 2007). Technology is changing rapidly. RFID technology will be an entirely different process for implementation and cost benefit analysis in just a few years. Managers must keep a close eye on changes in technology as well as the competition to keep up with trends and costs. They can expect major changes in technological standards in the future and must be willing to look at different options for RFID implementation to ensure success (Srivastava, 2004).

Costs can be drastically reduced and justified with the proper collaboration within the supply chain. Improving relationships, sharing the high capital costs, and democratically choosing technological standards will improve the likelihood of end users saving money and receiving better service.

Finally, RFID costs are mainly associated with upfront start-up costs. The ROI must be calculated with a long-term goal in mind. Training, equipment, and tags must all be purchased and updated as necessary to meet customer and supplier requirements. This technology seems very appealing, but must be calculated carefully to ensure proper investment for the firm.

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